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ASSESSING HEARING PROTECTOR DEVICE PERFORMANCE AND CALCULATING ALLOWABLE EXPOSURE DURATIONS IN HAZARDOUS NOISE

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This report reviews procedures used by base-level bioenvironmental engineers and technicians to determine appropriate personal hearing protection devices (HPD) and to calculate allowable exposure times for individuals wearing different HPDs in hazardous noise. Limitations of these procedures are discussed, and a preferred method is presented. Additionally, this report presents a BASIC program for use with noise dosimeter time history data which simplifies all the required calculations.

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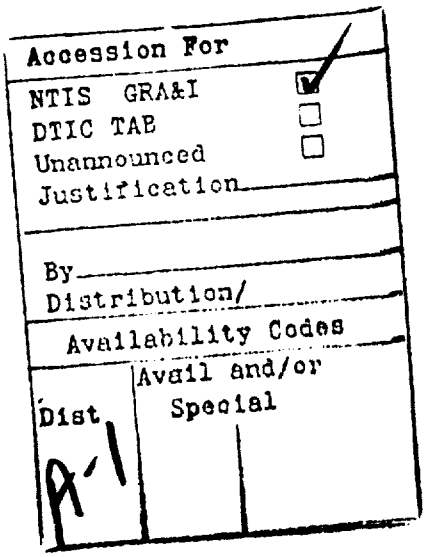

ASSESSING HEARING PROTECTOR DEVICE PERFORMANCE AND CALCULATING ALLOWABLE EXPOSURE DURATIONS IN HAZARDOUS NOISE

INTRODUCTION

Purpose

This report reviews procedures used by base-level bioenvironmental engineering services (BES) to determine appropriate personal hearing protection devices (HPDs) and to calculate allowable exposure times for individuals wearing different HPDs in hazardous noise. Limitations of these procedures are discussed, and a preferred method is presented.

Problem

The use of HPDs is the primary method used in the Air Force to protect individuals from hazardous noise exposure because of the inability to control noise emissions from aircraft engines. However, for environments where noise levels exceed 118 dB(A) for equivalent 8-hour exposures, even combinations of HPDs will not provide adequate attenuation for workers. Time limits must be used in addition to HPDs in such conditions. BES personnel have expressed difficulty in calculating the amount of time an individual can be exposed to noise while wearing various protectors, and workers have difficulty performing assigned tasks within assigned time limits.

Scope

This report outlines procedures currently used by many BES personnel for selection of HPDs and allowable noise exposure times using the tables in Air Force Regulation (AFR) 161-35. It then presents a preferred method using computer analysis of noise dosimetry time histories. This method has the potential for increasing allowable exposure times, which would reduce operational restrictions for workplaces such as jet engine test cells. This report does not address the problems associated with wearing dual HPDs during Chemical Warfare Task Qualification Training. This issue was addressed in a consultative letter (AL-CL-1992-0015)(5).

DISCUSSION

Current Method

BES is responsible for determining the appropriate hearing protection for the specific noise exposure. This is accomplished through the use of noise

level surveys. The initial survey identifies sources of hazardous noise (those $\geq$ 84 dB(A)) by recording A-weighted and C-weighted levels on the DD Form 2214, Noise Survey. Levels are either measured directly, using a sound level meter, or copied from appropriate volumes of the USAF Bioenvironmental Noise Data Handbooks. BES personnel typically use the HPD selection blocks on the DD Form 2214 to determine levels of protection required instead of comparing the frequency characteristics of the noise source against the performance of each HPD used. When using the DD Form 2214, single protection is required for noise sources $\geq$ 84 dB(A), double protection (plugs and muffs) for noise sources $\geq$ 108 dB(A), and double protection and time limits for sources >118 dB(A). HPD performance is used for the time limit calculation. HPD attenuation is dependent on the frequency content of the noise source and is listed in AFR 161-35, Table 3, as a function of the noise source's C-weighted sound level minus the A-weighted level (the "C-A" value). The effective at-the-ear sound level is calculated by subtracting the HPD's noise attenuation value from the source's A-weighted sound level. This effective exposure level is used to calculate the allowable exposure time from AFR 161-35, Table 5.

Noise dosimetry is also conducted by BES to measure the average daily noise exposure (Lavg) of workers. Most models of personal noise dosimeters in use by the Air Force offer a time history capability which allows a minute-by-minute look at the worker's noise exposure over the course of the duty day. While noise dosimetry is used extensively to decide whether or not to place workers on monitoring audiometry, it has not been used to determine effectiveness of HPDs.

Preferred Method

The preferred method that follows is a new procedure for calculating the effective noise attenuation of HPDs and allowable exposure times for the effective at-the-ear noise levels. Instead of using a single A-weighted noise level for a noise source at the operator's position, or the highest value at any position and power setting, it uses the average of the 1-minute noise levels from a noise dosimeter's time history. Using the time history allows us to account for lower noise levels when the worker is away from the loudest position or when the engine is at lower power settings. This method provides a more realistic value for a worker's noise exposure while wearing HPDs. The noise dosimeter time history shows, within 1 minute, how much time during the day the worker was exposed $\geq$ 84 dB(A). We can also calculate the average exposure level and exposure duration for specific operations.

To illustrate the application of the preferred method, let's examine the noise exposures of a worker at the leak check position on the F-4 aircraft positioned in a noise suppressor. The expected sound level (from Table 2, Volume 131 of the Noise Data Handbooks)(7) will range from 107 dB(A) at idle to 124 dB(A) at afterburner. Engine trim run operations can be identified in the noise dosimeter time history by selecting consecutive time intervals which are in the range 107 - 124 dB(A). There may be three or four separate engine runs during the day which can be easily identified in the time history.

Summing all the consecutive time intervals in the time history which have corresponding noise levels in the selected range will tell us precisely how long each day this worker is exposed to engine trim run noise. The software allows us to recalculate the average noise exposure level for engine trim runs alone. This average exposure level to the actual operation is the value which should be used to evaluate the hearing protection effectiveness.

Data Management Procedures and Software

The mechanics of analyzing noise dosimetry data using this preferred method are labor intensive when manually calculated. Analysis is simplified when data management procedures, developed by the Noise Hazards Function, AL/OEMI, are followed and noise dosimetry data is electronically filed. These procedures involve using ENABLE software to download the noise dosimeter time history reports to computer disk files (4). Ideally, a computer program would use A-weighted and C-weighted time history data collected simultaneously and calculate the frequency dependent performance of HPDs from these time histories; however, at the time of the analysis in this report, there was no method available to collect A-weighted and C-weighted time histories concurrently. Later electronic circuitry developments by Metrosonics, Inc. will allow this simultaneously recording (5) with an increased refinement in HPD assessments. These enhanced procedures will be available soon on the Electronic Information Exchange System (EIES)(6), Brooks Air Force Base, TX, by dialing toll free 1-800-288-0726 anywhere in the CONUS, Alaska, Hawaii, Puerto Rico and the Virgin Islands or (512) 536-3784. It will also be available on diskette through requests to the Noise Hazards Function, AL/OEMI at DSN 240-3214.

If you do not have the capability of simultaneously recording A-weighted and C-weighted time histories, you must be certain to collect the A-weighted and C-weighted values together (i.e., from the same sound level meter survey at the same measurement location). A wide range of C-A values can be obtained depending on where both the A-weighted and C-weighted noise levels are obtained. In selecting the appropriate HPD attenuation, the C-A value should be selected from the lowest C-A values (worst performance) from the DD Form 2214 or the Noise Data Handbooks; however, it is important to note that more than one single number attenuation value can be determined from the DD Form 2214. Table 1 illustrates the method used to determine the two C-A values used to analyze the time history data for personnel wearing the modified H-133 communication headset. We consider the C-A value for engine RPM at 100% and afterburner more important for this operation because of the overall higher noise levels present at these power settings.

Table 1. Single Number Attenuation Factors for the Modified H-133 Communications Headset

Engine Power Setting and Operator Location	Noise Level dB(C)	Noise Level dB(A)	C-A	Single Number Attenuation Factor (dBA)
1 Engine @ Idle 65%	104	102	2	29
1 Engine @ Mil Pwr 95%	124	124	0	31
1 Engine @ 100% & AB*	126	129	-3	31
Operator Position @ AB*	132	132	0	31

* AB = Afterburner

Example of Preferred Method

We illustrate the usefulness of this method with an actual consult from an Air National Guard Base which required wearing plugs and muffs and limited exposures to 1-hour maximum per day during RF-4C engine trims. The base BES supplied A-weighted and C-weighted sound level readings on the DD Form 2214 and a copy of A-weighted noise dosimetry time history data (Appendix A).

The time history report recorded on 24 Apr 90 was the worst exposure day (Lavg = 113.1 dB(A)) for the 5 days of monitoring (Appendix D, AF Form 2756). We selected this exposure because the selection of hearing protection should be based on the worst exposure day to ensure the greatest protection. We analyzed the dosimetry in two ways: analysis of only those time history intervals $\geq$ 84 dB(A) and analysis of intervals for specific source exposures. Each analysis was accomplished using both C-A values determined from the DD Form 2214.

Analysis of Intervals $\geq$ 84 dB(A)

Analysis of only those time history intervals $\geq$ 84 dB(A) is presented in Appendix B. The analysis was first performed by identifying those intervals with levels $\geq$ 84 dB(A) with an "X" in the flag column. The software program identified a total exposure time of 157.0 minutes from these flagged intervals, with an average sound exposure level of 119.6 dB(A) for the 157.0 minutes. The allowed exposure time was calculated using this data and the attenuation value for the H-133 modified headset in Table 3 - Single Number Attenuation Factors (dBA), in AFR 161-35, Hazardous Noise Exposure (1). The C-A attenuation factors were obtained using information on the DD Form 2214 supplied by the base (Table 1). Based on this worst case exposure, the maximum allowable exposure times for the modified H-133 were calculated. The individual's observed daily duration (ODD) of exposure of 157.0 minutes was divided by his limiting daily duration (LDD) for each C-A value to determine the fraction of his allowable daily exposure.

Table 2. Maximum Allowable Exposure Times for Noise Levels ≥ 84 dB(A)

Hearing Protector	Single Number Attenuation Factor (dBA)	At-the-Ear Exposure (dBA)	Maximum Allowed Exposure Time (LDD, minutes)	Allowed Time Remaining (minutes)	Fraction of Allowable Exposure (ODD/LDD)
Modified H-133 Comm	31	88.6	217.3	60.3	0.72
Headset	29	90.6	153.6	-3.4	1.06

Analysis of Intervals for Specific Source Exposures

The second analysis identified time intervals for specific source exposures, in this case, engine trim runs identified in the time history by either "I" (engine RPM at idle) or ">" (engine RPM greater than idle) (Appendix C). Whenever specific noise operations can be identified, hearing protection can be more appropriately matched for that noise source. When noise levels for operations are not clearly identifiable from the time history alone, further information is needed. Video taping, note taking, and discussions with the shop supervisor or workers may be necessary to match the time history exposure to actual noise operations.

Four engine runs were completed on 24 Apr 90 for a total actual exposure time of 92 minutes. An average sound exposure level of 122.6 dB(A) was calculated for the 92 minutes of engine operation. The allowed exposure time was calculated using this data and the attenuation value for the H-133 modified headset in Table 3 - Single Number Attenuation Factors (dBA), in AFR 161-35, Hazardous Noise Exposure. The C-A attenuation factors were obtained using information on the DD Form 2214 supplied by the base (Table 1). Based on this worst case exposure, the maximum allowable exposure times for the modified H-133 were calculated. The individual's observed daily duration (ODD) of exposure of 92.0 minutes was divided by his limiting daily duration (LDD) for each C-A value to determine the fraction of his allowable daily exposure.

Table 3. Maximum Allowable Exposure Times for Engine Runs

Hearing Protector	Single Number Attenuation Factor (dBA)	At-the-Ear Exposure (dBA)	Maximum Allowed Exposure Time (LDD, minutes)	Allowed Time Remaining (minutes)	Fraction of Allowable Exposure (ODD/LDD)
Modified H-133 Comm	31	91.6	127.5	35.5	0.72
Headset	29	93.6	90.2	-1.8	1.02

Based on total actual exposure time of 92.0 minutes per day with an allowed exposure time of 127.5 minutes per day, as calculated from the noise dosimetry data for the individual in the engine shop, we found their noise controls were overly restrictive. We recommended they eliminate their control of limiting exposures to a maximum of 1 hour per person per day. Based on the conditions in our example, there was sufficient time remaining for continued exposure before rotation of personnel was necessary. Should the actual exposure time increase beyond the 127.5 minutes of allowed exposure time, they must either 1) enforce the total allowed exposure time; 2) evaluate another hearing protection device; or 3) incorporate additional administrative controls.

Calculating Exposures to Multiple Operations

The amount of time an individual can spend exposed to multiple noise sources or operations depends on the noise levels and HPDs used for each operation. The effects of all operations in a work day can be calculated by adding the fraction of allowable exposure (ODD/LDD) for each operation, as outlined in AFR 161-35, paragraph 21.b., Calculating Limiting Values - Two or More Independent Exposures Each Workday. This states that daily noise exposures are within limits when the summed exposures do not exceed one (1.0). This is expressed mathematically as:

$$ODD1/LDD1 + ODD2/LDD2 + ODD3/LDD3 + \ldots + ODDn/LDDn \leq 1.0$$

CONCLUSIONS

- AFR 161-35 does not clearly describe a method for the BES to make an informed decision on the selection of appropriate hearing protection devices.

- A preferred method and computer program are presented which permits BES technicians to calculate allowable exposure times for individuals wearing various HPDs in hazardous noise environments.

- The mechanics of analyzing noise dosimetry data using this preferred method are labor intensive when manually calculated. The calculation of multiple C-A values from AF Forms 2214 presents a problem in deciding which factor is the most appropriate for determining the adequacy of the HPD. Analysis is simplified and more accurate when data management procedures, developed by the Noise Hazards Function, AL/OEMI, are followed and noise dosimetry data is electronically filed.

- This preferred method requires a software program designed for use with the noise dosimetry time history to calculate the allowed exposure time for individuals wearing various hearing protection devices. Recent developments in electronic circuitry have further enhanced the HPD assessment process by allowing the simultaneous recording of A-weighted and C-weighted time histories. This eliminates the multiple C-A values possible when using the DD Form 2214. This program will soon be available on the Electronic Information Exchange System (EIES) and on diskette through requests to the Noise Hazards Function, AL/OEMI.

- The selection of HPDs should be documented in the shop folders.

- Selection of the most appropriate HPD requires detailed knowledge of the noise environment which includes:
  - noise source levels (dB(A) and dB(C))
  - exposure duration
  - average exposure level dB(A)
  - time history exposure at 1-minute intervals matched to noise sources

- Since the definition of hazardous noise is based on exposure, we should use both the noise level and the duration of exposure to determine the adequacy of hearing protection and the allowable exposure limits. Time history noise dosimetry is the preferred method for estimating exposure. Sound level meter readings and Noise Data Handbooks are useful alternatives when time history dosimetry is not available.

- Using 1-minute time intervals provides adequate detail of how noise levels fluctuate for the workers during their duty day. This is the largest time interval recommended when applying the time history noise dosimetry data in the procedure for selecting or evaluating hearing protectors.

- Selection of hearing protection should be based on the worst exposure day to ensure greatest protection.

- Noise exposure data can be examined several different ways. Two ways given in this report were: all exposures $\geq$ 84 dB(A) (Appendix B) and specific source exposures (Appendix C).

- Whenever specific noise operations can be identified, hearing protection can be more appropriately matched for that noise source. We believe an average exposure level of the actual operation is the value which should be used to evaluate the effectiveness of hearing protection.

RECOMMENDATIONS

When HPDs and time limits are needed to control worker exposure to hazardous noise, use noise dosimetry time histories with the procedures described in this report to calculate the effectiveness of the HPDs and time limits.

REFERENCES

1. AFR 161-35, Hazardous Noise Exposure (9 April 1982).

2. Draft AFOSH Standard 161-19, Hazardous Noise Program (22 May 1991).

3. Draft AFOSH standard 161-20, Hearing Conservation Program (15 October 1991).

4. Ali, A. Y. Measuring Day-Night Noise Levels (DNL) Using the Metrosonics db-310 Sound Level Analyzer (Dosimeter), AF Occupational and Environmental Health Laboratory, Brooks AFB TX. AFOEHL Report 89-103EI0111JNA, September 1989.

5. Hopper, P. L. Noise Survey of Flightline Operations, Lincoln ANGB NE, Armstrong Laboratory, Brooks AFB TX. Consultative Letter AL-CL-1992-0015, February 1992.

6. Johnson, P. T. A User's Guide to the Armstrong Laboratory Electronic Information Exchange System (EIES Electronic Bulletin Board). Brooks AFB TX. AL-TR-1991-0053, April 1991.

7. Lee, R. A. USAF Bioenvironmental Noise Data Handbook: F-4 Aircraft in the AF32A-14 Noise Suppressor, Near and Far-Field Noise, Aerospace Medical Research Laboratory, Wright-Patterson AFB OH. AMRL-TR-75-50, Vol 131, February 1979.

APPENDIX A

Noise Dosimetry Time History

NOISE SOURCE CODE LISTING

Subject.....: Jet Engine Test Shop
Test Date.....: 04-24-1990
Dosimeter.....: Metrosonics db-310 SN 1146
Noise Source..: RF-4C at suppressor

X <==> Default Lavg RANGE: 84 $\leq$ Lavg $\leq$ 999
I <==> Idle Power
> <==> Engine RPM > Idle

TIME HISTORY

Subject.....: Jet Engine Test Shop
Test Date.....: 04-24-1990
Dosimeter.....: Metrosonics db-310 SN 1146
Noise Source....: RF-4C at suppressor

INT	TIME	Lavg	CODE	INT	TIME	Lavg	CODE
1	8:00:03	81.7		51	8:50:03	85.1	X
2	8:01:03	77.4		52	8:51:03	92.7	X
3	8:02:03	72.0		53	8:52:03	88.4	X
4	8:03:03	60.5		54	8:53:03	75.4	
5	8:04:03	65.0		55	8:54:03	68.2	
6	8:05:03	68.2		56	8:55:03	67.3	
7	8:06:03	86.7	X	57	8:56:03	77.0	
8	8:07:03	84.1	X	58	8:57:03	79.8	
9	8:08:03	84.3	X	59	8:58:03	79.8	
10	8:09:03	77.1		60	8:59:03	88.9	X
11	8:10:03	77.3		61	9:00:03	77.3	
12	8:11:03	77.4		62	9:01:03	68.5	
13	8:12:03	75.0		63	9:02:03	82.6	
14	8:13:03	83.8		64	9:03:03	66.6	
15	8:14:03	83.4		65	9:04:03	68.8	
16	8:15:03	72.5		66	9:05:03	72.5	
17	8:16:03	79.6		67	9:06:03	76.6	
18	8:17:03	78.3		68	9:07:03	82.7	
19	8:18:03	78.8		69	9:08:03	69.1	
20	8:19:03	88.7	X	70	9:09:03	75.9	
21	8:20:03	78.1		71	9:10:03	69.5	
22	8:21:03	93.2	X	72	9:11:03	75.4	
23	8:22:03	92.0	X	73	9:12:03	74.9	
24	8:23:03	87.8	X	74	9:13:03	64.6	
25	8:24:03	87.3	X	75	9:14:03	64.1	
26	8:25:03	88.5	X	76	9:15:03	76.0	
27	8:26:03	74.5		77	9:16:03	78.5	
28	8:27:03	77.4		78	9:17:03	66.7	
29	8:28:03	78.0		79	9:18:03	66.0	
30	8:29:03	86.3	X	80	9:19:03	70.5	
31	8:30:03	86.1	X	81	9:20:03	76.6	
32	8:31:03	92.9	X	82	9:21:03	79.0	
33	8:32:03	91.2	X	83	9:22:03	74.1	
34	8:33:03	87.0	X	84	9:23:03	74.5	
35	8:34:03	87.3	X	85	9:24:03	84.3	X
36	8:35:03	87.4	X	86	9:25:03	85.9	X
37	8:36:03	87.8	X	87	9:26:03	84.4	X
38	8:37:03	87.3	X	88	9:27:03	88.3	X
39	8:38:03	74.1		89	9:28:03	85.4	X
40	8:39:03	87.0	X	90	9:29:03	85.5	X
41	8:40:03	83.8		91	9:30:03	83.3	
42	8:41:03	84.0	X	92	9:31:03	62.4	
43	8:42:03	88.7	X	93	9:32:03	60.2	
44	8:43:03	90.5	X	94	9:33:03	61.6	
45	8:44:03	81.3		95	9:34:03	81.8	
46	8:45:03	72.1		96	9:35:03	76.4	
47	8:46:03	85.4	X	97	9:36:03	81.2	
48	8:47:03	84.6	X	98	9:37:03	80.6	
49	8:48:03	81.2		99	9:38:03	67.8	
50	8:49:03	86.3	X	100	9:39:03	72.6	

TIME HISTORY (Continued)

Subject.....: Jet Engine Test Shop
Test Date.....: 04-24-1990
Dosimeter.....: Metrosonics db-310 SN 1146
Noise Source....: RF-4C at suppressor

INT	TIME	Lavg	CODE	INT	TIME	Lavg	CODE
101	9:40:03	73.1		151	10:30:03	70.4	
102	9:41:03	90.2	I	152	10:31:03	72.7	
103	9:42:03	80.5		153	10:32:03	76.0	
104	9:43:03	103.7	I	154	10:33:03	78.1	
105	9:44:03	96.8	I	155	10:34:03	75.5	
106	9:45:03	98.1	I	156	10:35:03	77.7	
107	9:46:03	98.6	I	157	10:36:03	73.8	
108	9:47:03	98.2	I	158	10:37:03	75.9	
109	9:48:03	100.6	I	159	10:38:03	79.8	
110	9:49:03	108.0	>	160	10:39:03	73.3	
111	9:50:03	108.9	>	161	10:40:03	76.3	
112	9:51:03	110.2	>	162	10:41:03	76.6	
113	9:52:03	109.2	>	163	10:42:03	75.7	
114	9:53:03	111.1	>	164	10:43:03	76.9	
115	9:54:03	109.5	>	165	10:44:03	79.0	
116	9:55:03	111.9	>	166	10:45:03	79.4	
117	9:56:03	134.3	>	167	10:46:03	76.1	
118	9:57:03	131.3	>	168	10:47:03	74.1	
119	9:58:03	130.8	>	169	10:48:03	83.8	
120	9:59:03	128.1	>	170	10:49:03	78.3	
121	10:00:03	127.0	>	171	10:50:03	82.3	
122	10:01:03	118.5	>	172	10:51:03	90.0	X
123	10:02:03	120.0	>	173	10:52:03	87.8	X
124	10:03:03	111.8	>	174	10:53:03	86.0	X
125	10:04:03	128.3	>	175	10:54:03	78.2	
126	10:05:03	110.6	>	176	10:55:03	82.4	
127	10:06:03	105.4	I	177	10:56:03	83.2	
128	10:07:03	104.0	I	178	10:57:03	88.4	X
129	10:08:03	105.4	I	179	10:58:03	91.9	X
130	10:09:03	104.2	I	180	10:59:03	80.0	
131	10:10:03	104.0	I	181	11:00:03	85.4	X
132	10:11:03	103.6	I	182	11:01:03	83.4	
133	10:12:03	97.6	I	183	11:02:03	87.4	X
134	10:13:03	97.4	I	184	11:03:03	81.5	
135	10:14:03	123.7	>	185	11:04:03	76.2	
136	10:15:03	112.7	>	186	11:05:03	88.1	X
137	10:16:03	109.1	>	187	11:06:03	80.8	
138	10:17:03	93.9	I	188	11:07:03	85.1	X
139	10:18:03	93.1	I	189	11:08:03	90.5	I
140	10:19:03	91.6	I	190	11:09:03	99.9	I
141	10:20:03	79.2		191	11:10:03	102.0	I
142	10:21:03	79.6		192	11:11:03	99.9	I
143	10:22:03	68.2		193	11:12:03	105.2	>
144	10:23:03	79.9		194	11:13:03	110.7	>
145	10:24:03	82.3		195	11:14:03	126.2	>
146	10:25:03	73.4		196	11:15:03	132.8	>
147	10:26:03	74.5		197	11:16:03	137.6	>
148	10:27:03	78.1		198	11:17:03	128.3	>
149	10:28:03	82.9		199	11:18:03	115.7	>
150	10:29:03	75.5		200	11:19:03	99.3	I

TIME HISTORY (Continued)

Subject.....: Jet Engine Test Shop
Test Date.....: 04-24-1990
Dosimeter.....: Metrosonics db-310 SN 1146
Noise Source....: RF-4C at suppressor

INT	TIME	Lavg	CODE	INT	TIME	Lavg	CODE
201	11:20:03	90.4	I	251	12:10:03	72.7	
202	11:21:03	82.7		252	12:11:03	83.1	
203	11:22:03	77.6		253	12:12:03	70.5	
204	11:23:03	80.0		254	12:13:03	82.1	
205	11:24:03	79.8		255	12:14:03	81.9	
206	11:25:03	78.1		256	12:15:03	82.6	
207	11:26:03	79.2		257	12:16:03	77.2	
208	11:27:03	81.6		258	12:17:03	73.9	
209	11:28:03	79.3		259	12:18:03	83.3	
210	11:29:03	76.4		260	12:19:03	75.2	
211	11:30:03	82.0		261	12:20:03	77.3	
212	11:31:03	77.9		262	12:21:03	86.0	X
213	11:32:03	70.3		263	12:22:03	81.5	
214	11:33:03	68.3		264	12:23:03	88.4	X
215	11:34:03	73.8		265	12:24:03	81.9	
216	11:35:03	72.9		266	12:25:03	89.7	X
217	11:36:03	70.5		267	12:26:03	90.5	X
218	11:37:03	65.8		268	12:27:03	74.1	
219	11:38:03	68.8		269	12:28:03	70.9	
220	11:39:03	74.4		270	12:29:03	72.4	
221	11:40:03	70.7		271	12:30:03	82.4	
222	11:41:03	72.7		272	12:31:03	83.8	
223	11:42:03	70.2		273	12:32:03	86.0	X
224	11:43:03	69.6		274	12:33:03	72.3	
225	11:44:03	63.0		275	12:34:03	75.3	
226	11:45:03	67.4		276	12:35:03	69.7	
227	11:46:03	74.2		277	12:36:03	69.0	
228	11:47:03	76.3		278	12:37:03	74.8	
229	11:48:03	67.6		279	12:38:03	73.5	
230	11:49:03	66.2		280	12:39:03	83.8	
231	11:50:03	63.8		281	12:40:03	73.3	
232	11:51:03	68.8		282	12:41:03	70.0	
233	11:52:03	84.0	X	283	12:42:03	73.0	
234	11:53:03	75.2		284	12:43:03	69.5	
235	11:54:03	69.1		285	12:44:03	75.8	
236	11:55:03	68.1		286	12:45:03	72.0	
237	11:56:03	69.1		287	12:46:03	85.1	I
238	11:57:03	77.1		288	12:47:03	103.8	I
239	11:58:03	76.9		289	12:48:03	101.0	I
240	11:59:03	73.1		290	12:49:03	111.3	>
241	12:00:03	75.9		291	12:50:03	135.4	>
242	12:01:03	65.8		292	12:51:03	132.6	>
243	12:02:03	77.9		293	12:52:03	116.6	>
244	12:03:03	76.4		294	12:53:03	114.5	>
245	12:04:03	70.6		295	12:54:03	116.3	>
246	12:05:03	77.1		296	12:55:03	116.5	>
247	12:06:03	83.8		297	12:56:03	116.9	>
248	12:07:03	74.1		298	12:57:03	116.1	>
249	12:08:03	77.3		299	12:58:03	116.1	>
250	12:09:03	76.5		300	12:59:03	130.3	>

Subject.....: Jet Engine Test Shop
Test Date.....: 04-24 1990
Dosimeter.....: Metrosonics db-310 SN 1146
Noise Source....: RF-4C at suppressor

INT	TIME	Lavg	CODE	INT	TIME	Lavg	CODE
301	13:00:03	133.1	>	351	13:50:03	82.2	
302	13:01:03	129.3	>	352	13:51:03	84.0	X
303	13:02:03	131.2	>	353	13:52:03	77.3	
304	13:03:03	111.6	>	354	13:53:03	64.8	
305	13:04:03	112.4	>	355	13:54:03	70.2	
306	13:05:03	98.7	I	356	13:55:03	62.8	
307	13:06:03	92.1	I	357	13:56:03	65.6	
308	13:07:03	70.6		358	13:57:03	74.3	
309	13:08:03	67.6		359	13:58:03	74.3	
310	13:09:03	71.5		360	13:59:03	77.1	
311	13:10:03	86.9	X	361	14:00:03	78.4	
312	13:11:03	66.5		362	14:01:03	69.7	
313	13:12:03	65.0		363	14:02:03	73.1	
314	13:13:03	69.3		364	14:03:03	65.2	
315	13:14:03	68.6		365	14:04:03	72.2	
316	13:15:03	69.3		366	14:05:03	72.5	
317	13:16:03	78.0		367	14:06:03	72.2	
318	13:17:03	63.4		368	14:07:03	78.2	
319	13:18:03	73.6		369	14:08:03	79.0	
320	13:19:03	79.4		370	14:09:03	73.1	
321	13:20:03	68.6		371	14:10:03	66.5	
322	13:21:03	88.3	X	372	14:11:03	66.6	
323	13:22:03	68.4		373	14:12:03	75.0	
324	13:23:03	87.9	X	374	14:13:03	73.8	
325	13:24:03	72.6		375	14:14:03	67.1	
326	13:25:03	69.3		376	14:15:03	71.4	
327	13:26:03	79.6		377	14:16:03	87.2	X
328	13:27:03	80.4		378	14:17:03	64.3	
329	13:28:03	79.2		379	14:18:03	68.5	
330	13:29:03	83.1		380	14:19:03	68.8	
331	13:30:03	87.1	X	381	14:20:03	62.1	
332	13:31:03	84.4	X	382	14:21:03	77.8	
333	13:32:03	79.8		383	14:22:03	81.6	
334	13:33:03	76.2		384	14:23:03	68.2	
335	13:34:03	94.9	X	385	14:24:03	68.2	
336	13:35:03	80.0		386	14:25:03	73.2	
337	13:36:03	79.3		387	14:26:03	67.0	
338	13:37:03	87.3	X	388	14:27:03	83.4	
339	13:38:03	82.5		389	14:28:03	76.2	
340	13:39:03	77.6		390	14:29:03	86.1	X
341	13:40:03	78.7		391	14:30:03	87.7	X
342	13:41:03	80.2		392	14:31:03	93.3	I
343	13:42:03	83.9		393	14:32:03	96.7	I
344	13:43:03	77.3		394	14:33:03	98.5	I
345	13:44:03	77.1		395	14:34:03	111.0	>
346	13:45:03	80.3		396	14:35:03	99.9	I
347	13:46:03	81.0		397	14:36:03	100.5	I
348	13:47:03	75.3		398	14:37:03	100.2	I
349	13:48:03	75.9		399	14:38:03	100.0	I
350	13:49:03	80.1		400	14:39:03	100.2	I

TIME HISTORY (Continued)

Subject.....: Jet Engine Test Shop
Test Date.....: 04-24-1990
Dosimeter.....: Metrosonics db-310 SN 1146
Noise Source....: RF-4C at suppressor

INT	TIME	Lavg	CODE
401	14:40:03	103.4	I
402	14:41:03	100.3	I
403	14:42:03	109.2	>
404	14:43:03	109.4	>
405	14:44:03	113.3	>
406	14:45:03	131.1	>
407	14:46:03	110.7	>
408	14:47:03	99.1	I
409	14:48:03	96.8	I
410	14:49:03	102.3	I
411	14:50:03	94.0	I
412	14:51:03	72.4	
413	14:52:03	68.1	
414	14:53:03	89.2	X
415	14:54:03	86.4	X
416	14:55:03	71.6	
417	14:56:03	64.3	
418	14:57:03	62.7	
419	14:58:03	62.1	
420	14:59:03	70.7	
421	15:00:03	81.8	
422	15:01:03	82.0	
423	15:02:03	84.9	X
424	15:03:03	73.2	
425	15:04:03	66.0	
426	15:05:03	65.3	
427	15:06:03	67.2	
428	15:07:03	64.6	
429	15:08:03	72.2	
430	15:09:03	69.5	
431	15:10:03	62.9	
432	15:11:03	58.5	
433	15:12:03	64.2	
434	15:13:03	62.1	
435	15:14:03	70.4	
436	15:15:03	71.2	
437	15:16:03	64.8	
438	15:17:03	65.0	
439	15:18:03	66.6	
440	15:19:03	63.1	
441	15:20:03	63.0	
442	15:21:03	76.0	
443	15:22:03	74.6	
444	15:23:03	62.1	
445	15:24:03	59.6	
446	15:25:03	61.9	
447	15:26:03	67.0	
448	15:27:03	67.2	
449	15:28:03	71.7	
450	15:29:03	61.8	
451	15:30:03	69.6	
452	15:31:03	64.6	
453	15:32:03	65.4	
454	15:33:03	65.4	
455	15:34:03	74.1	
456	15:35:03	86.3	X
457	15:36:03	66.0	
458	15:37:03	67.7	
459	15:38:03	65.4	
460	15:39:03	73.1	
461	15:40:03	66.6	
462	15:41:03	64.2	
463	15:42:03	66.7	
464	15:43:03	69.1	
465	15:44:03	66.4	
466	15:45:03	64.3	
467	15:46:03	71.3	
468	15:47:03	64.5	
469	15:48:03	66.6	
470	15:49:03	75.1	
471	15:50:03	71.9	
472	15:51:03	72.1	
473	15:52:03	81.1	
474	15:53:03	69.0	
475	15:54:03	67.5	
476	15:55:03	68.0	
477	15:56:03	68.2	
478	15:57:03	74.0	
479	15:58:03	69.2	
480	15:59:03	72.3	

APPENDIX B

Hearing Protection Assessment Summary for Exposures At or Above 84 dB(A)

NOISE EXPOSURES ($\geq$ 84 dB(A))
DURING SUPPRESSOR OPERATIONS USING THE H-133 HEADSET

Subject	Jet Engine Test Shop
Test Date	04-24-1990
Archive Date	08-12-1991
Analysis Date	08-14-1991
Dosimeter	Metrosonics db-310 SN 1146
Noise Source	RF-4C at suppressor
Hearing Protection Device	H-133 (mod w/custom molded insert)
C-A Value	-2 thru 0
Selected Noise Codes	X, I, >
Total Minutes Minus Exposure Time	157.0 min
Average Sound Exposure Level (4 dB)	119.6 dBA
Attn from Hearing Protector	31.0 dBA
Effective at Ear Exposure	88.6 dBA
Total Allowed Exposure Time	217.3 min (3.6 hrs)
Allowed Time Minus Actual Exposure Time:	60.3 min *

Subject	Jet Engine Test Shop
Test Date	04-24-1990
Archive Date	08-12-1991
Analysis Date	08-14-1991
Dosimeter	Metrosonics db-310 SN 1146
Noise Source	RF-4C at suppressor
Hearing Protection Device	H-133 (mod w/custom molded insert)
C-A Value	1 thru 3
Selected Noise Codes	X, I, >
Total Minutes Minus Exposure Time	157.0 min
Average Sound Exposure Level (4 dB)	119.6 dBA
Attn from Hearing Protector	29.0 dBA
Effective at Ear Exposure	90.6 dBA
Total Allowed Exposure Time	153.6 min (2.6 hrs)
Allowed Time Minus Actual Exposure Time:	-3.4 min *

* All positive numbers represent adequate hearing protection (HP) attenuation values. Positive numbers represent the time remaining before the allowed exposure time is exceeded, and alternative controls are required. Negative numbers represent inadequate HP attenuation values. Negative numbers also represent the minutes the allowed exposure time is exceeded. If the number is negative you must either (1) enforce the total allowable exposure time, (2) evaluate another HPD, or (3) incorporate additional administrative controls.

APPENDIX C

Hearing Protection Assessment Summary for Specific Source Exposures

NOISE EXPOSURES
FOR ENGINE TRIM OPERATIONS USING THE H-133 HEADSET

Subject	Jet Engine Test Shop
Test Date	04-24-1990
Archive Date	08-12-1991
Analysis Date	08-14-1991
Dosimeter	Metrosonics db-310 SN 1146
Noise Source	RF-4C at suppressor
Hearing Protection Device	H-133 (mod w/custom molded insert)
C-A Value	-2 thru 0
Selected Noise Codes	I, >
Total Minutes Minus Exposure Time	92.0 min
Average Sound Exposure Level (4 dB)	122.6 dBA
Attn from Hearing Protector	31.0 dBA
Effective at Ear Exposure	91.6 dBA
Total Allowed Exposure Time	127.5 min (2.1 hrs)
Allowed Time Minus Actual Exposure Time	35.5 min *

Subject	Jet Engine Test Shop
Test Date	04-24-1990
Archive Date	08-12-1991
Analysis Date	08-14-1991
Dosimeter	Metrosonics db-310 SN 1146
Noise Source	RF-4C at suppressor
Hearing Protection Device	H-133 (mod w/custom molded insert)
C-A Value	1 thru 3
Selected Noise Codes	I, >
Total Minutes Minus Exposure Time	92.0 min
Average Sound Exposure Level (4 dB)	122.6 dBA
Attn from Hearing Protector	29.0 dBA
Effective at Ear Exposure	93.6 dBA
Total Allowed Exposure Time	90.2 min (1.5 hrs)
Allowed Time Minus Actual Exposure Time	-1.8 min *

* All positive numbers represent adequate hearing protection (HP) attenuation values. Positive numbers represent the time remaining before the allowed exposure time is exceeded, and alternative controls are required. Negative numbers represent inadequate HP attenuation values. Negative numbers also represent the minutes the allowed exposure time is exceeded. If the number is negative you must either (1) enforce the total allowable exposure time, (2) evaluate another HPD, or (3) incorporate additional administrative controls.

APPENDIX D

DD Form 2214
and
AF Form 2756

DATE _____ SIG _____
DATE _____ SIG _____
DATE _____ SIG _____

NOISE SURVEY
(Sound Level Meter Survey)

Date (YYMMDD): 89.05.02 | Type of Survey: INITIAL

	Sound Level Meter	Microphone	Calibrator
Mfg:	GEN RAD	N/A	GEN RAD
Model:	1565-B		1562-A
Serial #:	27217		20799
Calib. Date:	89.04.06		89.05.22

Wind Screen: NOT USED | Measurements Obtained: INSIDE

Description of Areas/Duties Where Noise Survey Conducted (Illustrate on another sheet of paper):

ENGINE RUN-UP AT AIRCRAFT SOUND SUPPRESSOR. DURING TEST ADJUary Noise Source STS AND CHECKS ENGINE UNDER AIRCRAFT DURING OPERATIO-60 ENGINE STARTER

Primary Noise Source: RF4 ENGINE

Sound Level Data | Protection Req'd (re: dBA)

Location	Act	dBC	dBA	RAC	None <85	P/M 85-105	P&M 105-115	P+M+TL >115
OPERATORS POSITION D-60 STARTR	S	105	102	3B		XX		
1 ENGINE AT IDLE=65%	S	104	102	3B		XX		
1 ENGINE AT MILITARY POWER 99%	S	124	124	3A				XX
1 ENGINE AT 100% & AFTERBURNER	S	128	129	3A				XX
OPERATOR POSITION UNDER RF4C	S	132	132	2B				XX
POWER AIR CART AM32A-95, IDLE	S	95	92	3C		XX		
POWER AIR CART AM32A-95, 100%	S	105	103	3B		XX		
PUMP HOUSE COMPRESSOR	S	91	84	3C	XX			

Notes: 1) Range of levels noted by "/"; i.e. 102/109. At operator work stations, measure at ear level.
2) Meter Action: Enter F for fast meter action and S for slow
3) P=Earplugs, M=Earmuffs, TL=Time Limit

Remarks (i.e. Area and equipment posted, hearing protection, etc.

ALL MOBIL EQUIPMENT WHICH WAS USED IN CONJUNCTION WITH AIRCRAFT OPERAT ION WAS MONITORED AT OPERATORS POSITION. DUE TO SAFETY CONCERNS ALL ENGINE NOISE MONITORING WAS CONDUCTED AS CLOSE AS ALLOWABLE BY TECHS PERFORMING THE RUN-UP FUNCTIONS.

More Detailed Noise Evaluation Required? Y (If "Yes", explain)
8 HR TWA

Names of Persons Identified for Audiometric Monitoring:
ALL SHOP PERSONNEL

Name, Phone #, and Organization of Supervisor of Noise-Hazardous Area
SMSGT SAPP

Survey Performed By: (Last, First, MI)	Hearing Conservation Monitor: (Last, First, MI)
TSGT J.W. ENNIS 90770	TSGT FAHRENHOLZ

DD Form 2214 (Computer Generated)
Aug 79

DATE _____ SIG _____
DATE _____ SIG _____
DATE _____ SIG _____

NOISE SURVEY
(Sound Level Meter Survey)

Date (YYMMDD): 90.05.02 | Type of Survey: INITIAL

	Sound Level Meter	Microphone	Calibrator
Mfg:	GEN RAD	N/A	GEN RAD
Model:	1565-B		1562-A
Serial #:	27217		20799
Calib. Date:	89.06.06		89.05.22

Wind Screen: NOT USED | Measurements Obtained: INSIDE

Description of Areas/Duties Where Noise Survey Conducted (Illustrate on another sheet of paper)

VARIOUS PNUEMATIC/ELECTRIC POWER TOOLS USED THROUGH OUT SHOP DURING DIFFERENT PHASES OF ENGINE MAINTENANCE

Primary Noise Source
EQUIPMENT SPECIFIED

Secondary Noise Source
LIGHT BACKGROUND

Sound Level Data | Protection Req'd (re: dBA)

Location	Act	dBC	dBA	RAC	None <85	P/M 85-100	P&M 100-110	P&M&TL >110
STATIONARY GRINDER ELECTRIC	S	82	80	NA	XX			
PNEUMATIC IMPACT WRENCH	S	97	101	3C		XX		
AIR DRILL	S	100	101	3C		XX		
HIGH SPEED MINI GRINDER	S	89	88	4C		XX		
ELECTRIC DRILL	S	95	96	3B		XX		
PALM HELD PNEUMATIC WRENCH	S	99	104	3B		XX		
ELECTRIC ETCHER ON TURBINE FRM	S	100	102	3B		XX		
ULTRA SONIC CLEANER (PARTS RM)	S	92	96	3C		XX		

Notes: 1) Range of levels noted by "/"; i.e. 102/109. At operator work stations, measure at ear level.
2) Meter Action: Enter F for fast meter action and S for slow
3) P=Earplugs, M=Earmuffs, TL=Time Limit

Remarks (i.e. Area and equipment posted, hearing protection, etc.

WITH THE EXCEPTION OF THE ULTRA SONIC CLEANER, MONITORING OF EQUIPMENT WAS PERFORMED AT OPERATORS POSITION APPROXIMATELY EAR LEVEL. THESE VARIOUS TOOLS ARE USED ON A ROUTINE BASIS. HEARING PROTECTION WAS IN USE ALTHOUGH EQUIPMENT WAS NOT POSTED AS HAZARDOUS NOISE PRODUCING. ULTA SONIC CLEANER WAS MONITORED W/THE LID OPEN-BUT WAS OVER W/LID CLOSED.

More Detailed Noise Evaluation Required? Y (If "Yes", explain)
8HR TWA

Names of Persons Identified for Audiometric Monitoring:
ALL SHOP PERSONNEL

Name, Phone #, and Organization of Supervisor of Noise-Hazardous Area
SMSGT SAPP

Survey Performed By: (Last, First, MI)	Hearing Conservation Monitor: (Last, First, MI)
TSGT J.W. ENNIS 90770	TSGT FAHRENHOLZ

DD Form 2214 (Computer Generated)
Aug 79

NOISE SURVEY (DOSIMETER)		Workplace Identifier: 0331-FAJM-008A	
(Use this space for mechanical imprint) VERIFIED CURRENT DATE _____ SIG _____ DATE _____ SIG _____ DATE _____ SIG _____ DATE _____ SIG _____		Name: LINCOLN NEANG	Organization: 155 CAMERON
		Workplace: ENGINE SHOP	
		Bldg No./Location: 605	Room/Area
	Manufacturer	Model	Serial No.
Dosimeter Calibrator	METROSONICS METROSONICS	DB-310 CL-303	VARIED/DAY 038

Calibration Date: 88.06.01 Exchange Rate: 4 dBA Range: 43 to 143 dBA

NOISE EXPOSURE DATA

Survey Date Noise Type Sources		90.04.24 INTERUPTED RF/4 ENGINE	90.04.25 INTERUPTED RF/4 ENGINE	90.04.27 INTERUPTED SHOP TOOLS	90.04.30 INTERUPTED RF/4 ENGINE	90.05.01 INTERUPTED SHOP TOOLS
M N T R	Model SN Init Calib Final Cali	DB-310 1146 43.4-143.4 43.4-143.4	DB-310 1104 43.1-143.1 43.1-143.1	DB-310 1104 43.3-143.3 43.2-143.2	DB-310 1146 43.5-143.5 43.4-143.4	DB-310 1104 43.1-143.1 43.4-143.4
Employee SSAN or survey loc						
Mic location		COLLAR	COLLAR	COLLAR	COLLAR	COLLAR
> 115 dBA?		Y	Y	N	Y	N
Start time Stop time Total time		0800 1600 8.0	0800 1600 8.0	0800 1600 8.0	0800 1600 8.0	0800 1600 8.0
Display Readin ECL (dBA)		0.00 113.10	0.00 101.10	0.00 81.00	0.00 105.10	0.00 79.40

Remarks & Calculations: Ave noise exposure level, ECL(40.0)=105.7 dBA

LPK OVER ON 90/04/24 & 90/04/25 & 90/04/30, DUE TO PERFORMING RF4 TRIM RUNS & ENGINE RUN-UPS

EXISTING CONTROLS	DATA APPLICABILITY
[ ] None [ ] Plugs or muffs [ ] Plugs & muffs [Y] Plugs & muffs & time limit of: 1 hrs [ ] Engineering Controls:	[ ] Max risk worker [X] Representative [X] One worker only
Surveyed by (Name, Grade, AFSC) TSGT JW ENNIS 90770	Reviewed by (Name, Grade, AFSC)

AF Form 2756 (Computer Generated) 1
Apr 91

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